METERON – Validating Orbit-to-Ground Telerobotics Operations Technologies

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METERON – will be a platform to provide ‘educated answers’ to the question of how future “operator in space” robotic mission architectures need to be implemented!
METERON = Multi-Purpose End-To-End Robotic Operation Network –
An experiment & architecture to validate human-robotic operations from space using the ISS

PRIMARY GOALS

- ROBOTICS
  - Technology Validation
  - Telepresence in space (-μG) environment
  - Shared-autonomous control

- OPERATIONS
  - End-To-End Mission simulation
  - Multi-homed control centers
  - Real-time (~ ms) mission operations

- COMMUNICATIONS
  - Disruption/Delay Tolerant Networking
  - Real-time comm’s
Why do we want to use ISS for such research under METERON?

On Ground, it is ...

- IMPOSSIBLE to simulate microgravity,

- DIFFICULT to simulate the environment factors (mental load, comm’s, etc.),

- SENSELESS To simulate the complexity of the infrastructure and operation processes.

ISS currently is the most realistic environment that resembles future manned exploration missions! *We want to use it, because ‘we can’. *
Mission Architecture
METERON
Reference Architecture – e.g. Mars exploration
METERON
Concept of METERON System

ISS:
Crewed Orbiter

Earth Mission Control

Rover/Robot Communications

Rover Control Center

Experiment / Ref Mission Architecture
Robotic Experiment
• Exact analysis of advanced Human-Robot Interface performance in highly constraint environments (for control of robotic mobility, manipulation and mobile manipulation).

End-point devices: e.g., Phantom, Delta/Omega Devices, Force-feedback Joysticks, etc.

Function only under gravity!
METERON
Robotics Experiments – On-board segment up-grade

ISS Robotic Control Station

ERA / SSRMS
Manipulator Arms

State Control

EUROBOT / JUSTIN
Humanoid Robot Partners

State Control

State Feedback
Robotic Technology
METERON
Robotic Technology:: Exoskeleton – X-Arm-2

[A. Schiele and G. Hirzinger, IEEE IROS 2011, submitted]
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Robotic Technology: EUROBOT – Ground Prototype

[F. Didot, P. Schoonejans et al., ASTRA 2006]
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Robotic Technology:: Rollin’ JUSTIN

(Courtesy: DLR RM, Oberpfaffenhofen)

[C. Borst et al., IEEE ICRA 2009]
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Robotic Technology:: Robonaut R2

(Courtesy: NASA JSC, General Motors Inc.)

System Implementation
Experiment Sequence
Experiments will be implemented incrementally, in two phases

- **PHASE 1: - Dec. 2010**
  - Demonstrate feasibility of robotics experiments by preparing missing technologies and showing sub-system feasibility of exoskeleton and robot control up to TRL-5 and -6.
  - Increment 0 (ongoing)

- **PHASE 2: - 2015**
  - Investigate benefit of haptics and immersive technologies for remote robot operations on astronaut performance from within a highly constrained zero-G environment.
  - Increments 1 – 5
Increment 1
Topology

LEGEND
- DTN Network
- Real-Time Control
- Other Ground Network

Ground System Implementation
Supervisory control experiments
Non Body-grounded F.-Feedback + Mobility control
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Phase 2 – Increment 4

Body-grounded F.-Feedback + Real-time 7 d.o.f. control
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Phase 2 – Increment 5

Increment 5
Topology

Fully immersive teleoperation incl. 3D stereo feedback (ODAR availability)
Thank you!